Application of Adaptive Gridding in FUN3D for Simulation of Flow over a Nose Landing Gear

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Category 4: Partially Dressed Cavity Closed Nose Landing Gear (PDCC-NLG)

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Objectives

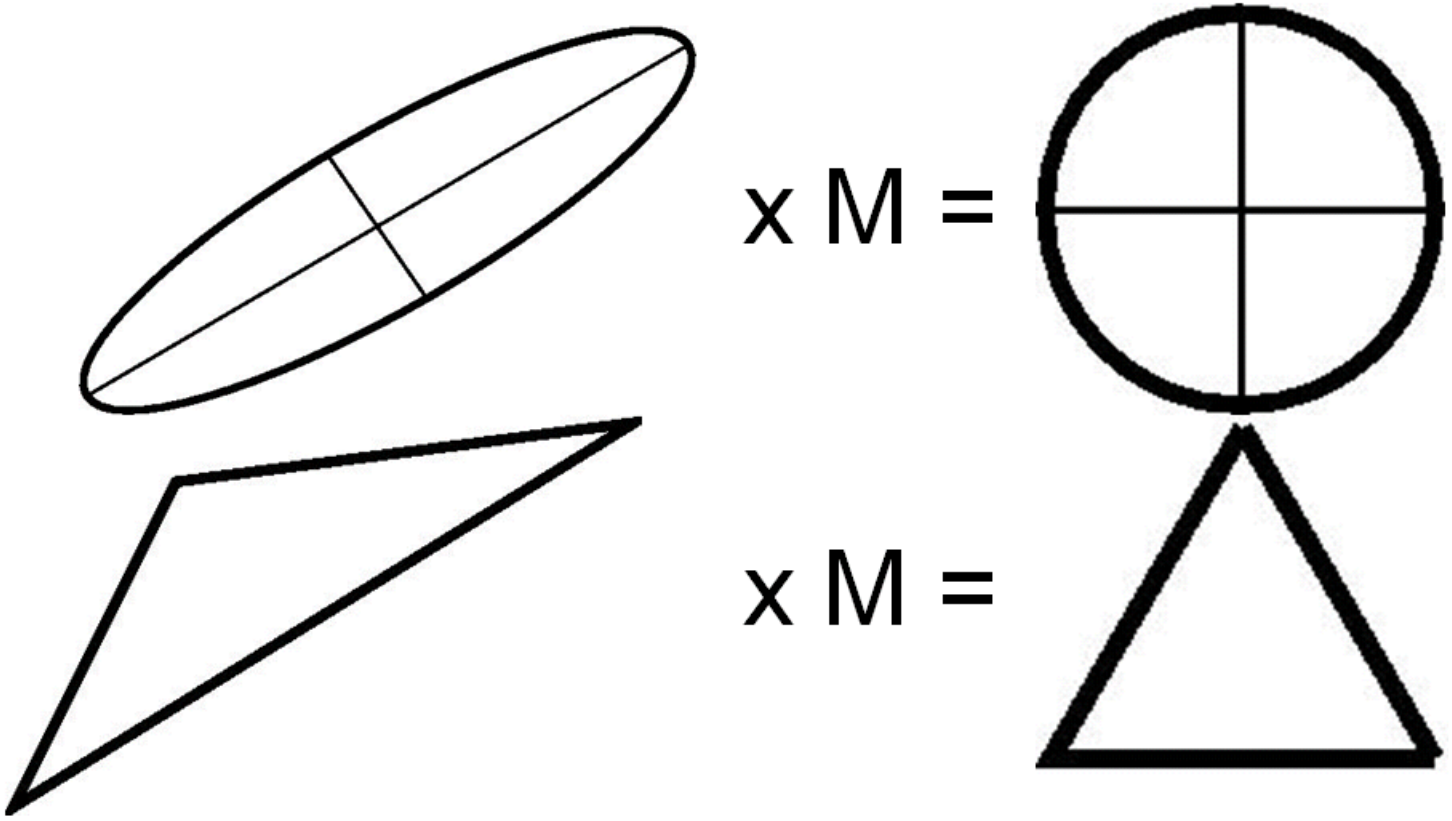
- Explore the use of adaptive grid capability in FUN3D code for simulating the flow over Gulfstream Nose Landing Gear configuration
- Develop a simpler grid generation process and reduce computational costs
- Compare the resulting solutions with the baseline solutions on manually enriched unstructured grids

Grid Adaption: Technical Background

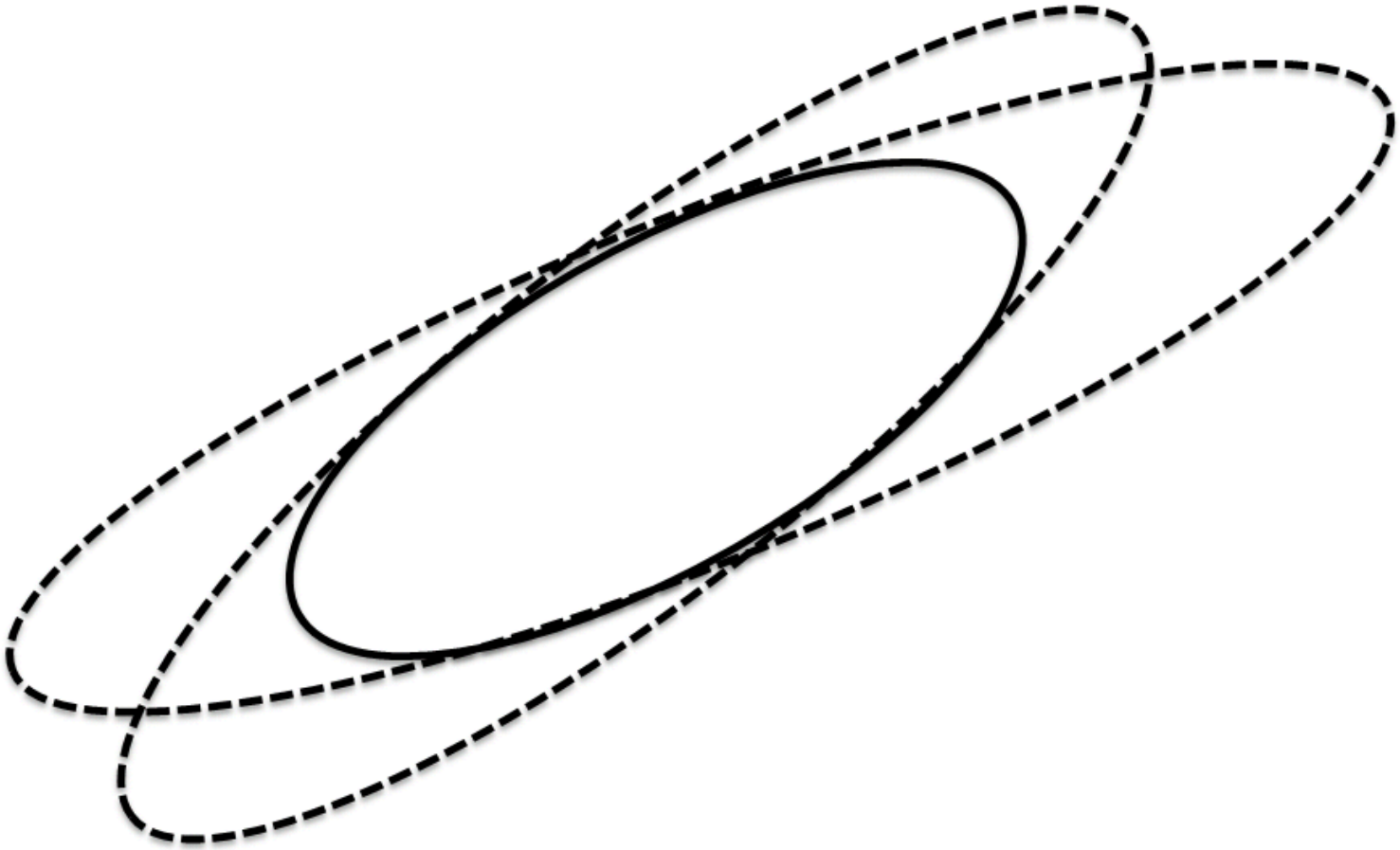
- The grid adaption approach based on the “Metric Intersection” scheme described by Alauzet et al., and Loseille and Alauzet of INRIA and adopted in FUN3D unstructured grid flow solver
  - *Int. J. Numer. Meth. Fluids, vol. 43, pp. 729-745, 2003*
  - *SIAM J. Numeric. Analysis, vol. 49, No.1, pp. 38-60, 2011*
- Use vorticity based Hessian for grid adaption
- For unsteady problems, most restrictive estimate of the metric constructed over a time interval is used to resize grids
  - Both refinement and coarsening permitted

Metric

- General approach to define to anisotropic grid resolution



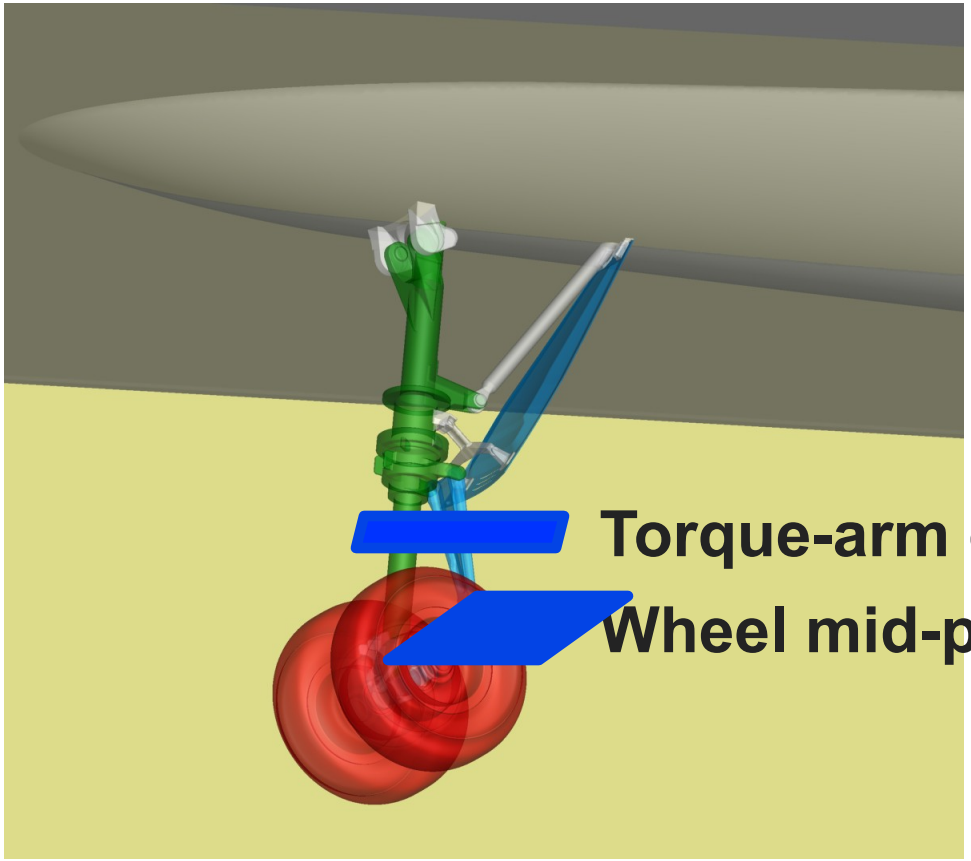
Metric Intersection: Schematic



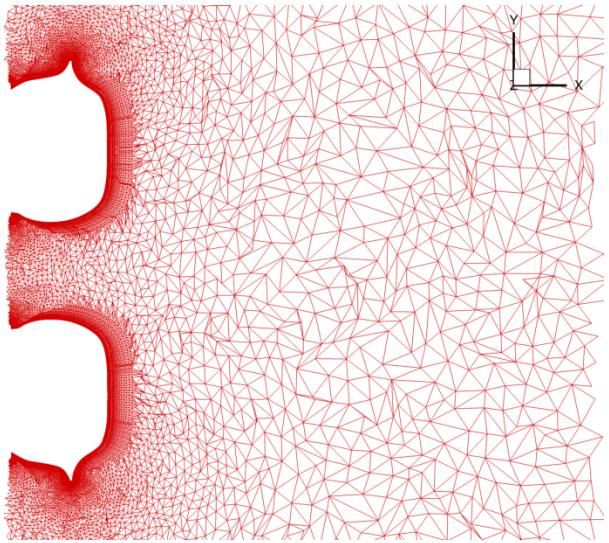
Grid Adaption Process

- Generate an unstructured grid for solid surfaces and adjacent boundary layer regions
  - Current process does not refine surface grids – need to start with adequate resolution for surface grids
  - Create a coarse initial volume grid, much simpler compared to creating fine grids with locally enriched grids in high gradient regions
    - Avoids need for apriori knowledge of flow field
- Run the FUN3D code in time-accurate mode on the initial coarse grid
  - Use vorticity based Hessians for metric construction
  - Determine the most restrictive metric over a selected time interval
  - Use the metric from previous step in conjunction with adaption mechanics to resize grid cells
- Once a new grid is created, repeat the process for next cycle
  - Repeat adaption until desired accuracy is achieved

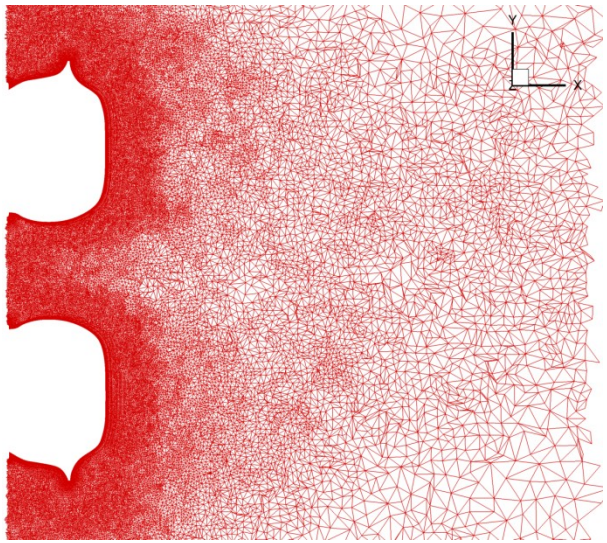
Sample grid cuts



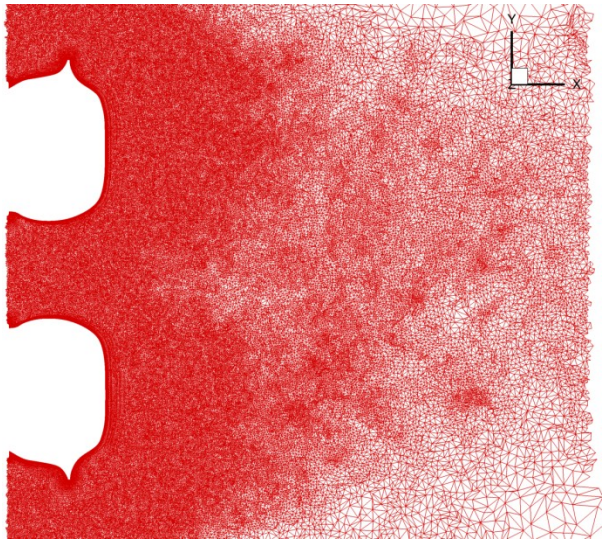
Comparison of Grids at Wheel mid-plane



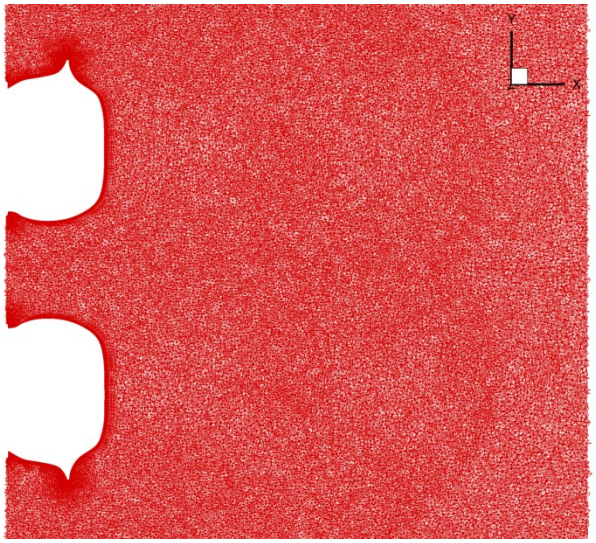
Initial grid: 18M (adpt0)



Medium grid: 32M (adpt1)

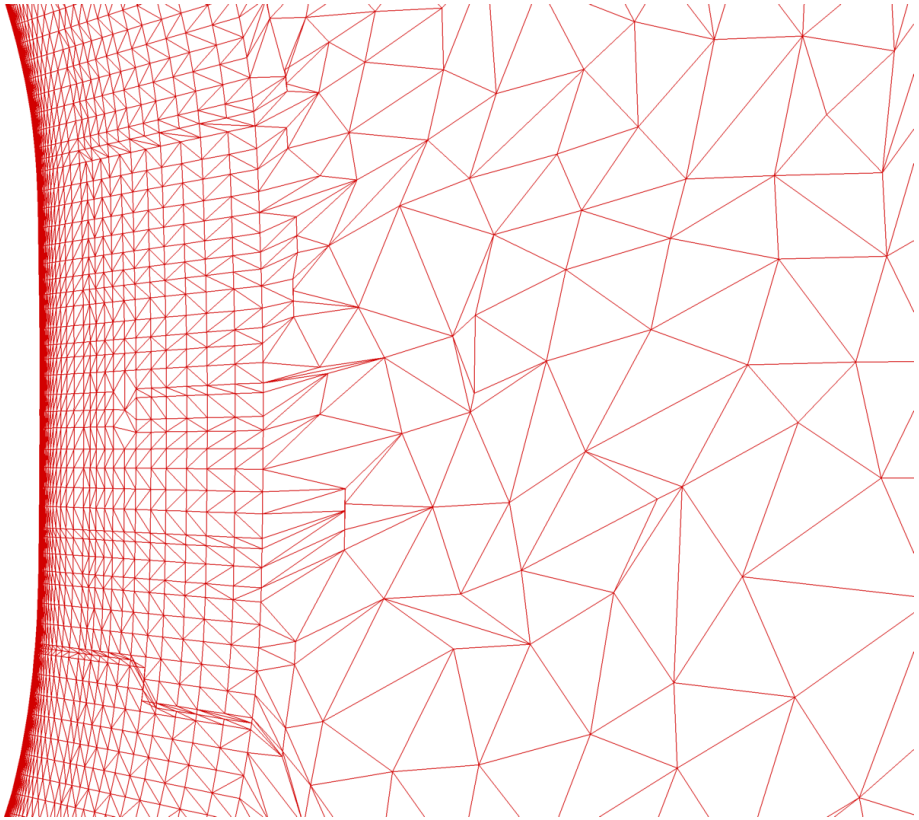


Finer grid: 65M (adpt2)

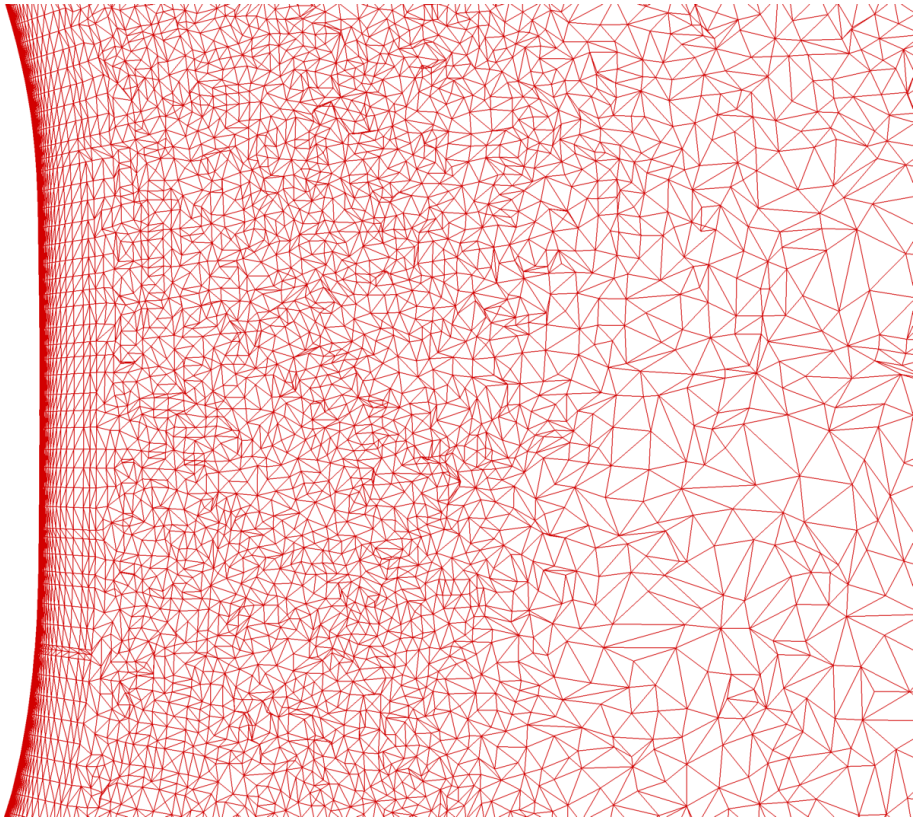


Reference grid: 145M

Comparison of Grids at Wheel mid-plane – zoomed view I

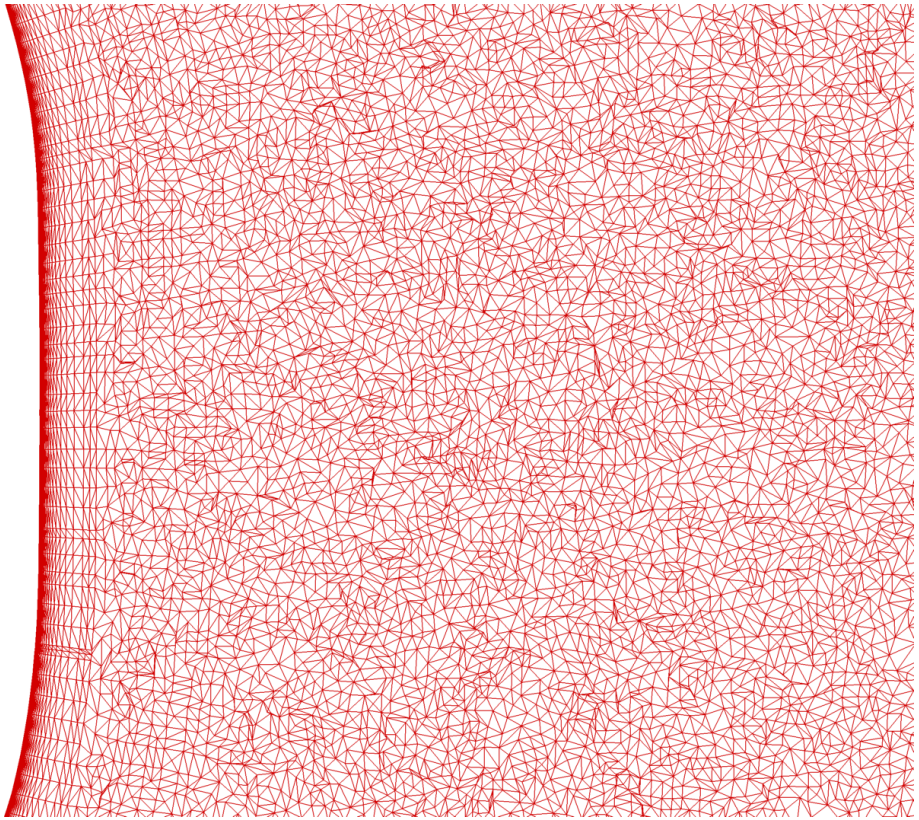


Initial grid: 18M (adpt0)

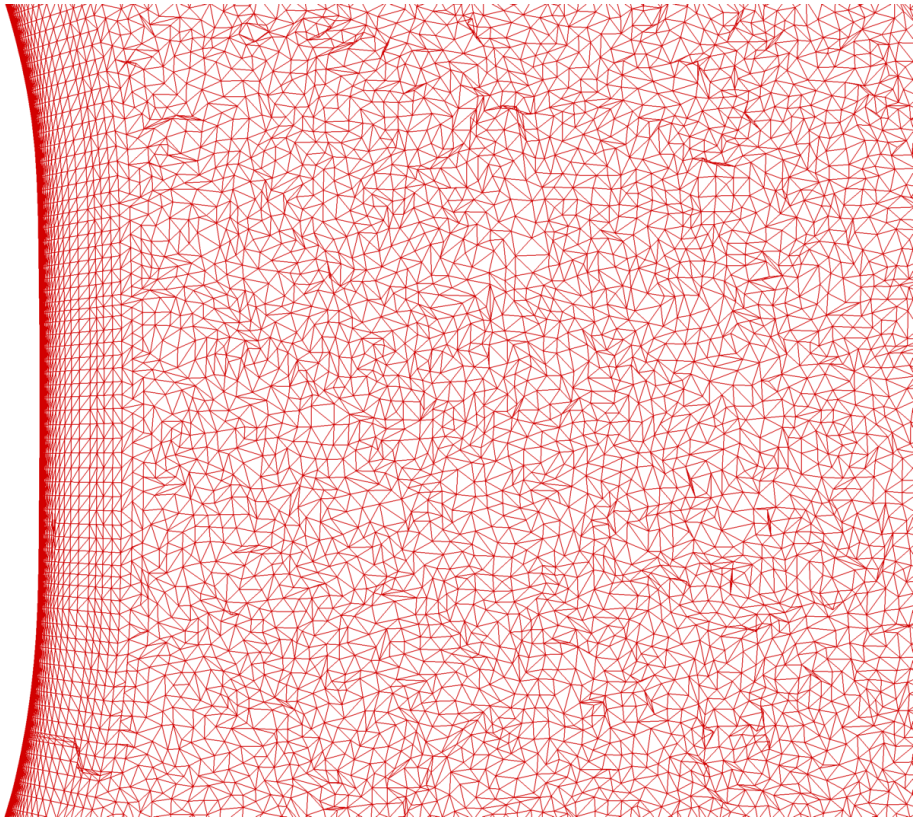


Medium grid: 32M (adpt1)

Comparison of Grids at Wheel mid-plane – zoomed view II

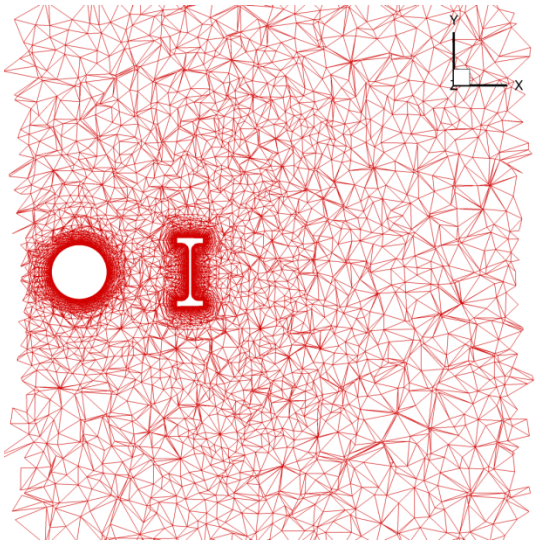


Finer grid: 65M (adpt2)

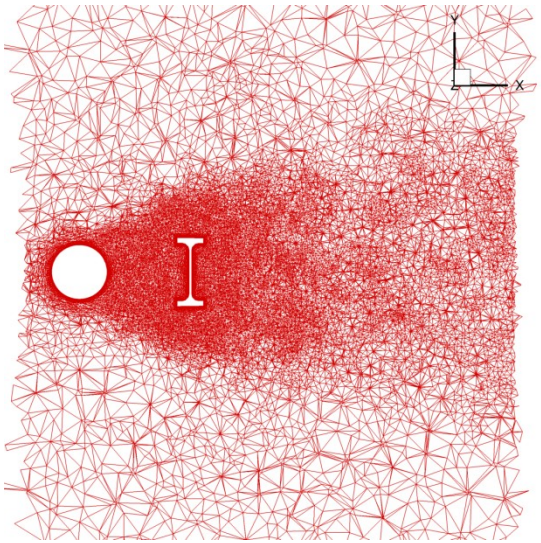


Reference grid: 145M

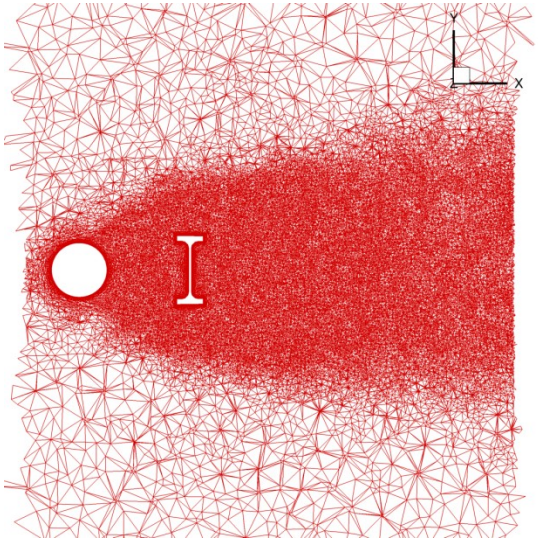
Comparisons of Grids at Torque-arm cut



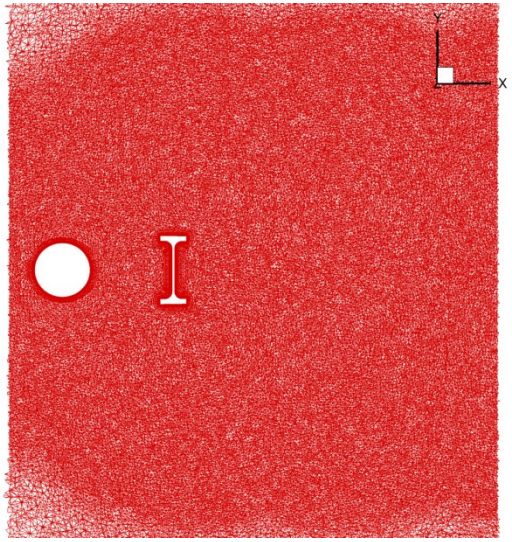
Initial grid: 18M (adpt0)



Medium grid: 32M (adpt1)

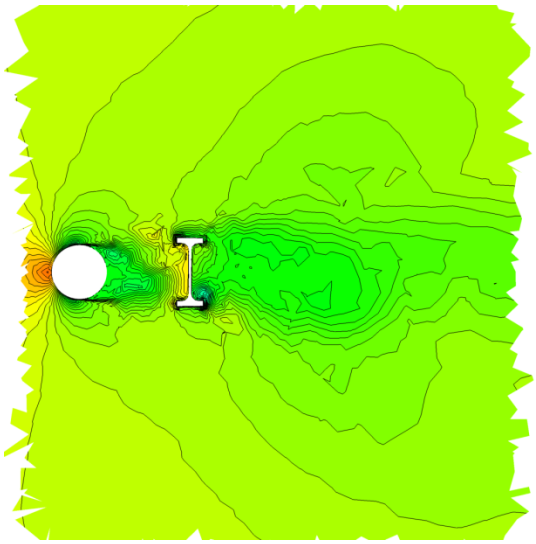


Finer grid: 65M (adpt2)

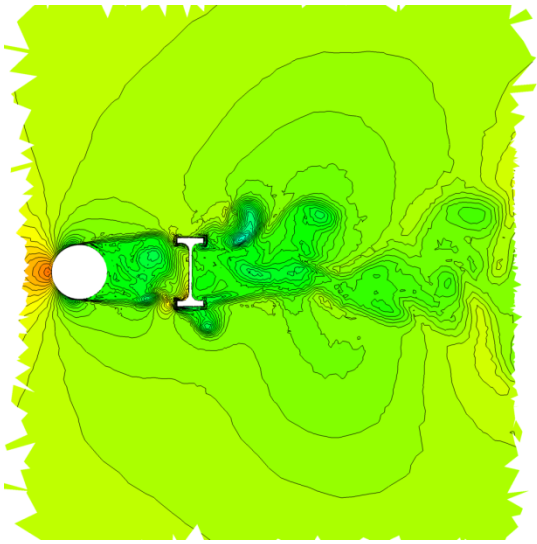


Reference grid: 145M

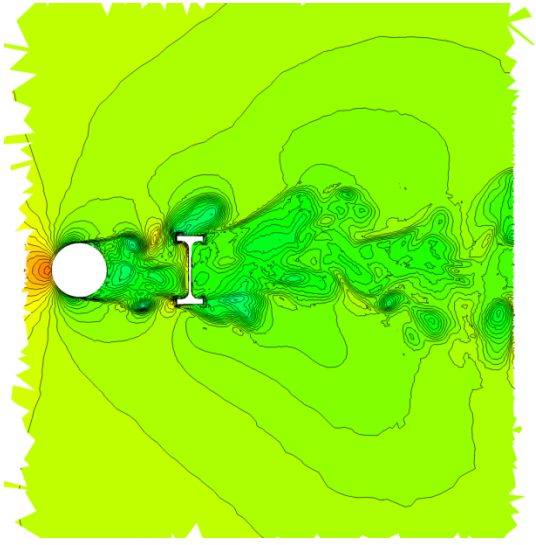
Comparisons of Instantaneous Density Contours along Torque-arm cut



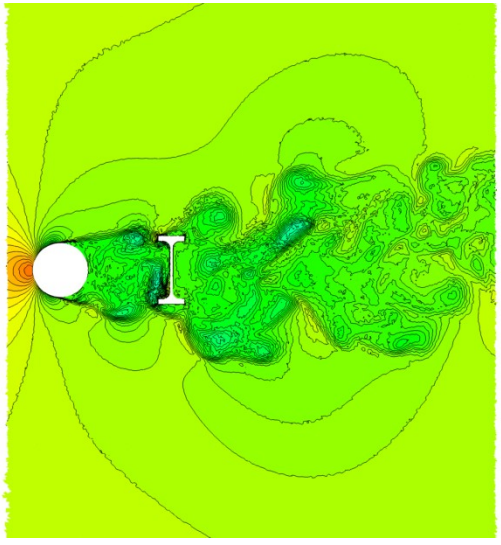
Initial grid: 18M (adpt0)



Medium grid: 32M (adpt1)

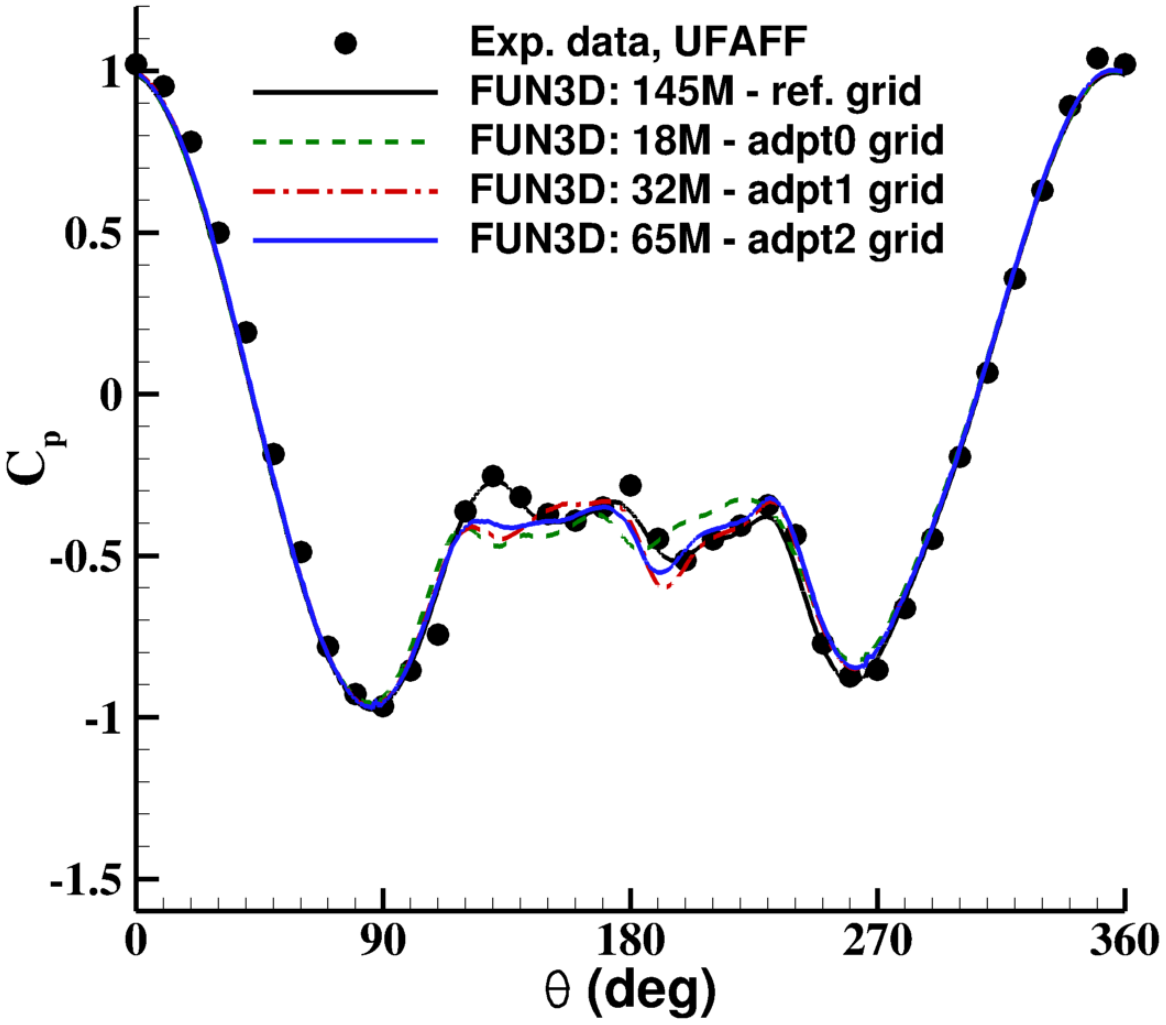


Finer grid: 65M (adpt2)

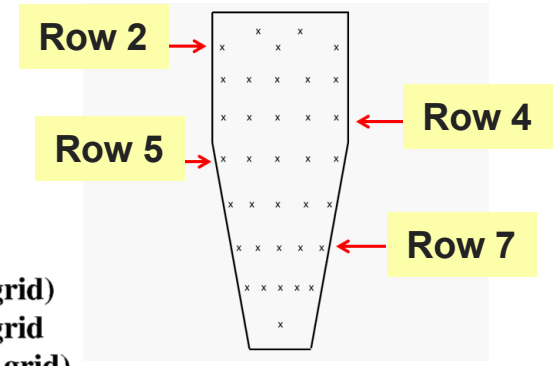


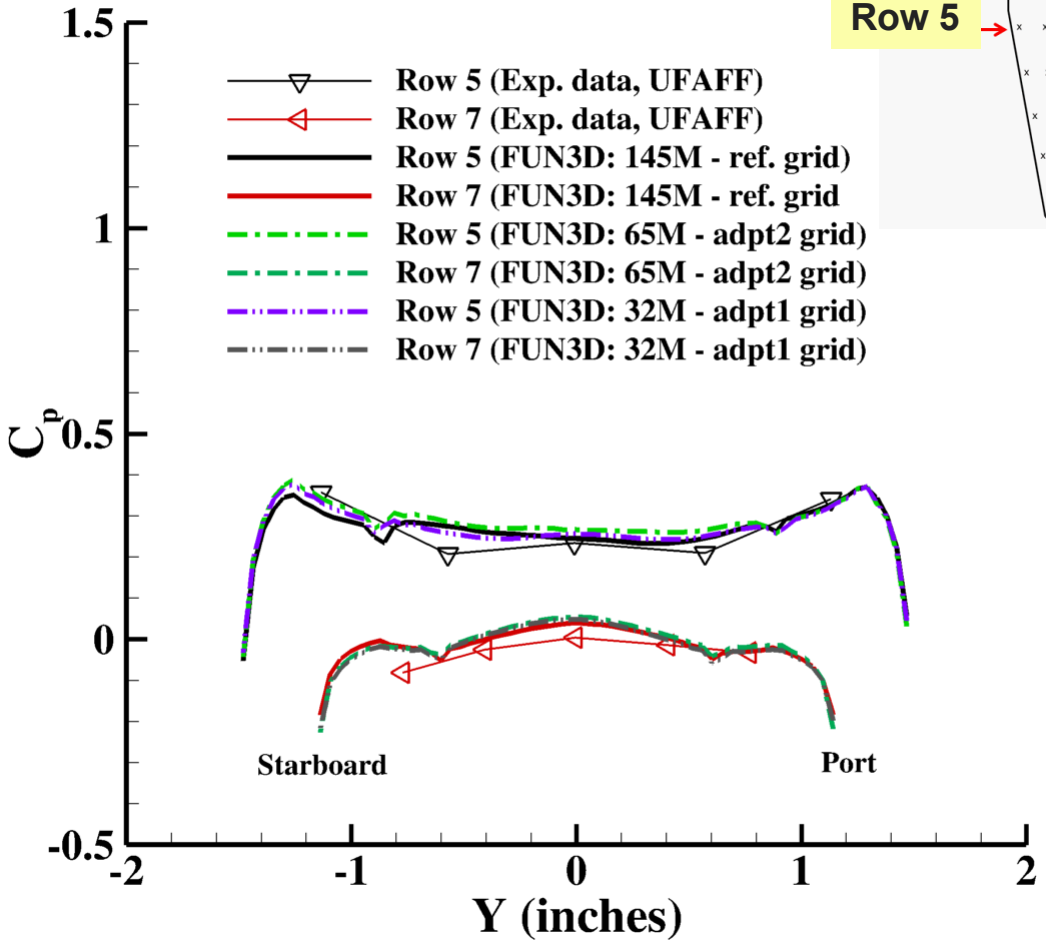
Reference grid: 145M

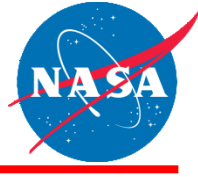
Surface Pressure Comparisons (Starboard Wheel)



Surface Pressure Comparisons at Door (Rows: 5 and 7)



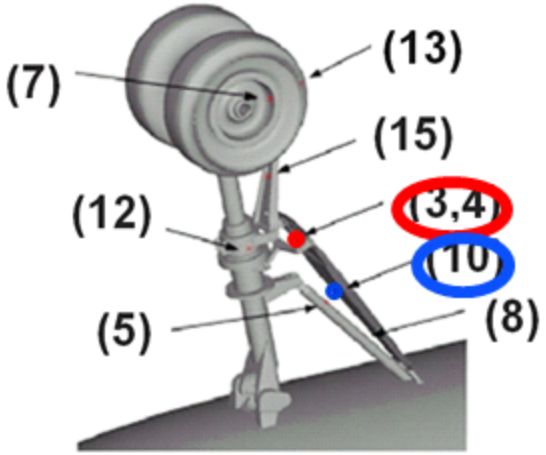


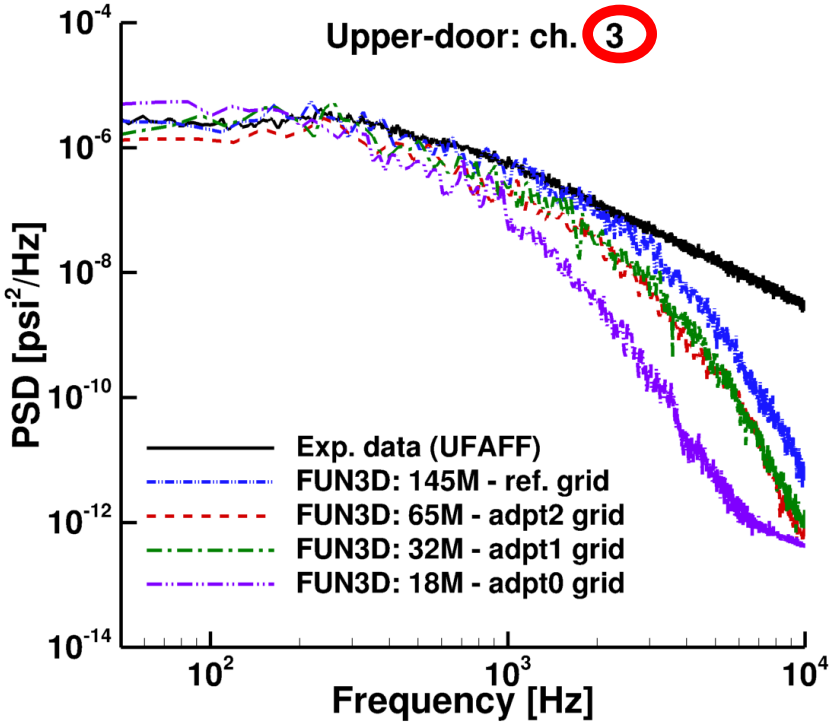


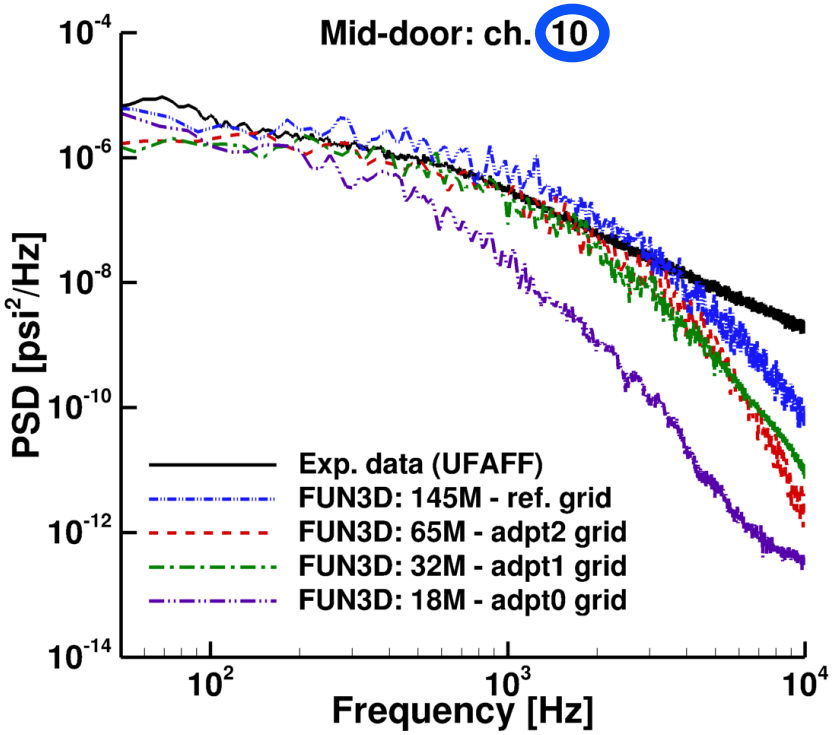
Unsteady data comparisons

Effect of Grid Refinement on Power Spectral Density Distributions - I

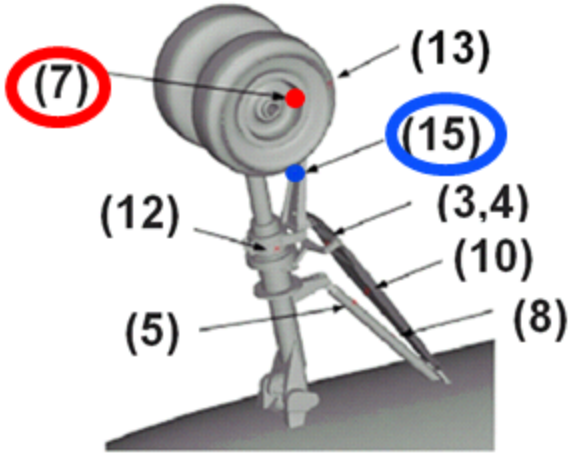
- PSD levels improve with grid refinement

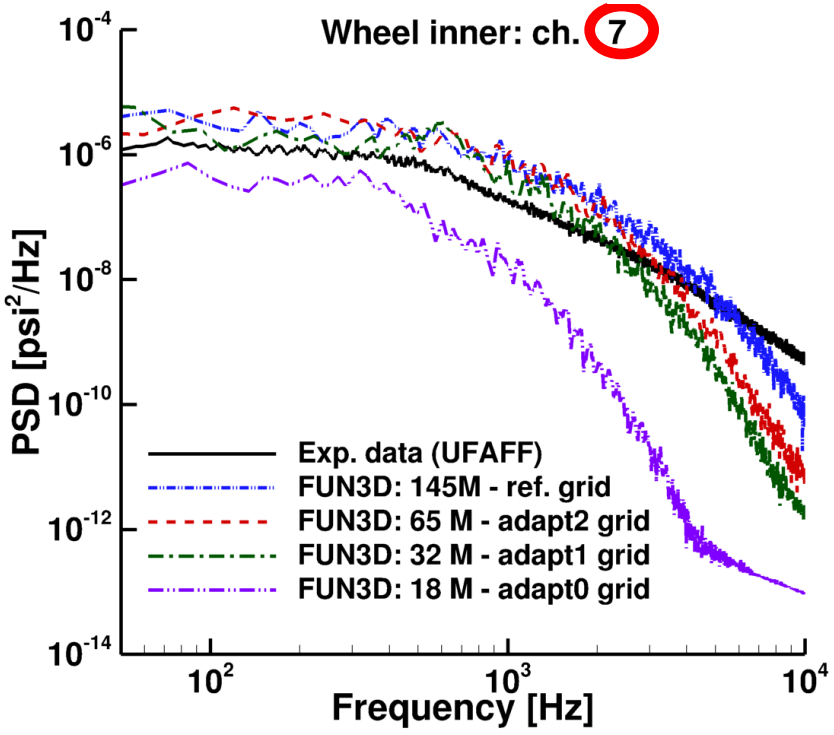


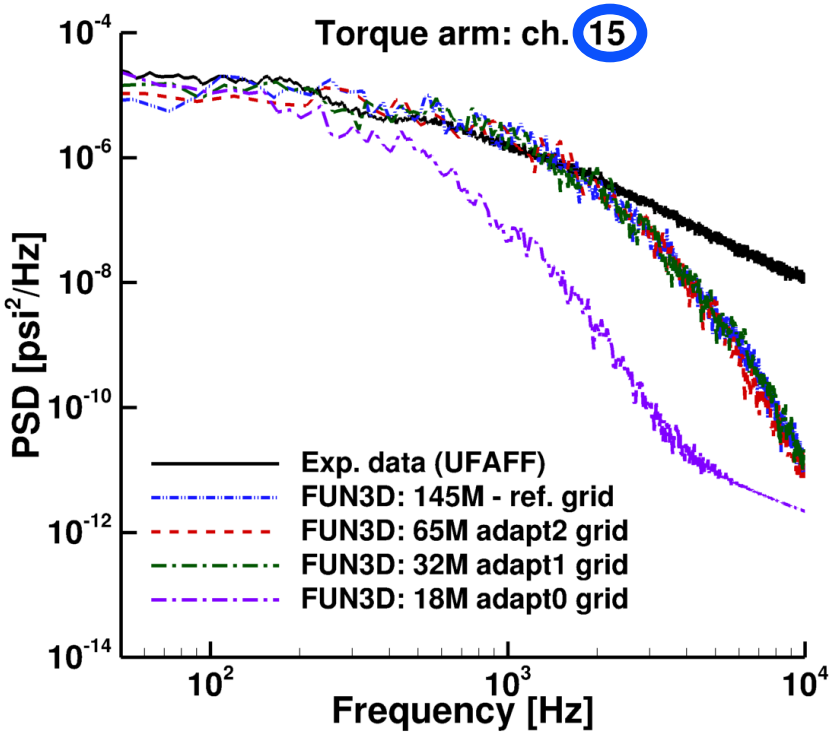




Effect of Grid Refinement on Power Spectral Density Distributions - II







Concluding Remarks

- Demonstrated grid adaption capability of the unstructured grid flow code FUN3D for simulating the unsteady flow over PDCC-NLG configuration
- Solution accuracy improves with successive grid refinements
- Proposed approach offers simplification of grid generation process for complex configurations
  - Start with coarse volumetric grids
  - Use the adaptive grid capability to enrich grids as needed
- Computed results on adaptive grids encouraging

Questions/Comments